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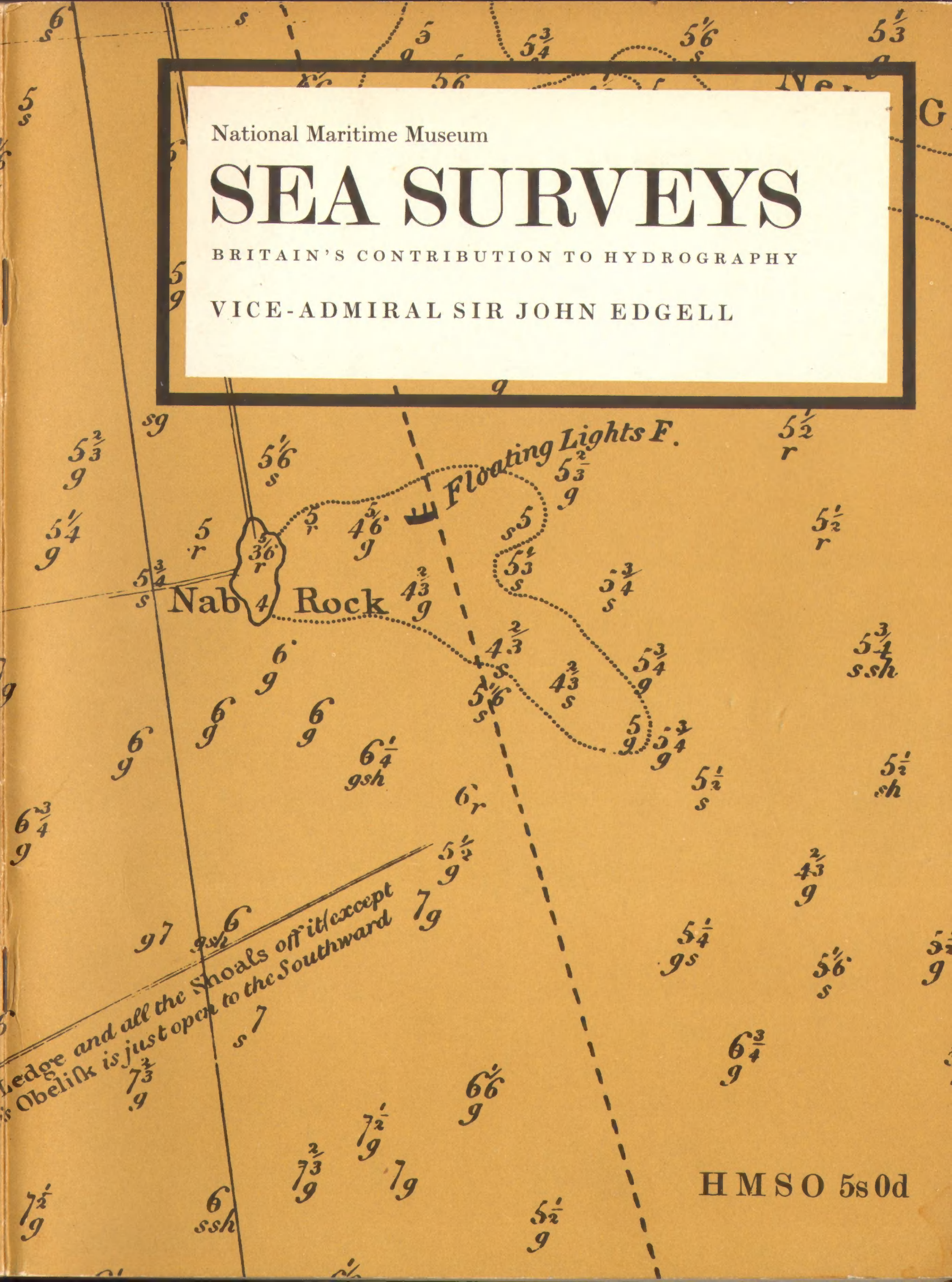
SEA SURVEYS

BRITAIN'S CONTRIBUTION TO HYDROGRAPHY

VICE-ADMIRAL SIR JOHN EDGELL



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The above is the title of Admiralty Chart No. 15, "*Published according to Act of Parliament Oct.r 1st. 1808 by Cap. Hurd, R.N.*, Hydrographer *to the* Admiralty," of which a part is reproduced, approximately twice full size, on the cover. This chart was not superseded until 1852.

National Maritime Museum

SEA SURVEYS

Britain's contribution to hydrography

VICE-ADMIRAL SIR JOHN EDGELL
KBE, CB, FRS

Hydrographer of the Navy, 1932–1945

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SEA SURVEYS

1. THE EARLY HYDROGRAPHERS

ODDLY enough the first voyage of which there is any detailed record did not end in disaster; we are told that 'the ark *rested* in the seventh month, on the seventeenth day of the month, upon the mountains of Ararat'. This event would not properly be classed as shipwreck, and there were no casualties, but the voyage was scarcely one of exploration, for the vessel merely drifted.

When man first began to make use of the seas, lakes and rivers for purposes of transport, it is fair to assume that consideration was given to the provision of some sort of guide either in the way of maps or in the use of simple sailing directions. Much of the lore of the sea was no doubt passed on from seaman to seaman, committed to memory at first, and recorded in hieroglyphics or writing when progress made this possible. All early voyages of any length must have been largely exploratory and dependent on a fair wind, for it was not until about the middle of the seventeenth century that large ships began to beat to windward and so overcome the handicap hitherto imposed on their movements by the elements. It is not surprising therefore that our knowledge of the position and shape of the greater land masses was very imperfect and remained so for centuries. Of the smaller land masses, suffice it to say that Madeira was discovered by the Portuguese only 500 years ago.

Exploration and discovery go hand in hand with hydrography, and numerous early voyagers kept careful record of their journeys, and in particular described the coasts seen by them and the meteorological conditions experienced. It is fortunate that so many were keenly observant and capable of putting in writing and on the chart the material which they collected, thus providing a permanent record for the benefit of posterity.

The days of discovery at sea are nearly ended, and except in the Arctic and Antarctic there is little that is not known about the general position and extent of the land masses and island groups. Not that they are by any means adequately charted; in fact, in many places this is far from being the case. Doubt still persists as to the existence of a few isolated islets in the Pacific Ocean, but these will surely be resolved in the course of the next few years, either by the seaman or airman in his passage from port to port. The accurate delineation of the coastline, however, and the determination of the depth of water relative to the coast, will continue to be the responsibility of the hydrographical surveyor, who is the legitimate successor of the old-time explorer. We seamen owe a lot to the tenacity of purpose and spirit of adventure which animated the voyagers of old, and such names as Cabot, Drake, Frobisher and

Raleigh will always be held in honour. Others of a later date—Cook, Flinders, Vancouver and Ross, to mention but a few—showed the way to modern chart-makers, and depend for their fame no less on the accuracy of their invaluable work than on the tenacity of purpose which overcame all obstacles to its achievement.

It is the purpose of this monograph to trace the development of hydrography in Great Britain and the Commonwealth. The contributions of navigators of other nations to the charting of the seas are well known: Vasco da Gama, Columbus, Magellan, Van Diemen, Tasman, Bougainville and many others by discovery and clear thinking helped to pave the way to a proper appreciation not only of the shape of the earth but of the possibilities of navigating in any part of the oceans.

The difficulties attendant on navigation were by no means confined to the art of sailing and seamanship; perhaps the greatest problem which baffled the seamen and scientists alike was how to determine the position of a ship when out of sight of land. A ship's position is known when her latitude and longitude are determined. The determination of latitude was a relatively simple matter, but the determination of the amount of easting or westing made good, that is to say, of change of longitude, was for long impossible. Since difference of longitude is determined by measuring the difference in time between places, the longitude problem could be solved at sea best by the development of accurate marine timekeepers. Until then, longitude determination was dependent on 'dead' (i.e. estimated) reckoning. Since little or no information was available regarding the behaviour of ocean currents, the effects of leeway, and even the accurate estimation of the speed of a ship through the water, the accumulated error of longitude in a long voyage often amounted to hundreds of miles. The solution of this problem became a matter of great urgency to all maritime nations; learned societies all over Europe were engaged in investigations and in England in the year 1714 the Board of Longitude was set up and a prize of £20,000 offered to anyone who could devise a method whereby the longitude could be calculated within reasonable limits. The Board continued its investigations until 1828 but the prize may be said to have been fairly won in the year 1762 when John Harrison, a Yorkshire carpenter, perfected his fourth marine timekeeper and gave to the world an accurate watch with a steady rate, that is to say, one which could be relied upon to lose or gain a very small but regular amount each day.* Wireless time signals which are now in general operation the world over have to some extent reduced the need for dependence on the chronometer's behaviour, but for 200 years Harrison's invention, little altered by later makers, held undisputed sway over the navigation of the high seas, and on the accurate performance of the chronometer depended the geographical position of all places overseas.

The early history of hydrographical surveying is inseparable from that of

* Harrison's timekeepers are on view at the National Maritime Museum.

discovery and exploration; these in their turn depend upon a thirst for knowledge and the quest for trade. There can be little doubt that so far as trade is concerned, the desire, if not the need, to establish such relations with lands overseas acted as a spur to the merchant adventurers, and British seamen responded readily to the incentives of strange voyages, the hope of discovering new lands and the possibility of reaping some profit from the venture. There was indeed ample adventure to stir the spirit and imagination of those bold and fearless navigators who, knowing little or nothing of what lay beyond, and inadequately provided with ships and gear, yet put to sea resolved to do their utmost to accomplish something of note and to bring back their harvest of facts and conclusions. More than any others, these bold and energetic seamen 'smote for us a pathway to the ends of all the Earth'.

The study of early maps and charts clearly illustrates the development of cartography. The realisation of the true shape of the earth and of the existence of the magnetic poles, and knowledge of the change in the value of magnetic variation, all contributed to a more accurate delineation of the coastal features; attention was naturally directed to methods of drawing on a flat surface what in actual fact was spheroidal. It is to Gerardus Mercator that the navigator owes the first chart whereon meridians and parallels were drawn as straight lines.

On a Mercator chart the meridians and parallels are straight lines at right angles to one another, so that any angle laid off from a given position will cut all the meridians at the same angle, and distances can be accurately measured in terms of sea miles. This, however, is done only at the expense of considerable distortion, since the meridians are drawn equally spaced through the longitude divisions at the equator; the parallels have to conform to the expanded positions of the meridians, and are therefore not equally spaced. It will be apparent that the Mercator chart cannot be constructed near the poles.

The Mercator projection is still in general use for small-scale charts despite the fact that it was first used in the year 1569; since that date many other projections have been made use of for general and special purposes. The gnomonic projection is that more usually employed for chart work.

The function of a gnomonic chart is to show the shortest distance between two positions. Its meridians are straight lines which converge slightly towards the poles, and the parallels are curved; for small areas this curvature is inappreciable except in high latitudes (60° and more).

2. THE HYDROGRAPHERS OF THE BRITISH NAVY

It was not until the year 1795 that the Hydrographic Office of the Admiralty was established, and so little attention had been given to hydrography in the Royal Navy that it was deemed necessary to appoint a Mr. Alexander Dalrymple to the post of Hydrographer, a position which he had held for

many years with the Honourable East India Company. The Board of Admiralty Minute is dated August 12, 1795, and runs as follows:

> 'The great inconvenience especially when ordered abroad, felt by officers commanding His Majesty's ships respecting the navigation, has led us to consider the best means for furnishing such information, and preventing the difficulty and danger to which His Majesty's fleet must be exposed from defects on this head.
>
> On an examination of charts in office, we find a mass of information requiring digest, which might be utilised, but owing to the want of an establishment for this duty, His Majesty's officers are deprived of the advantages of these valuable communications.
>
> In other countries, considerable establishments have been formed for this object.
>
> We therefore propose that a proper person be fixed upon to be appointed Hydrographer to the Board, to be entrusted with the care of such charts etc., as are now in office, or may hereafter be deposited, and to be charged with the duty of collecting and compiling all information requisite for improving Navigation, for the guidance of Commanders of H.M. ships.
>
> The extent of such an establishment not to exceed the sum of £650 per annum, in aid of which, £100 a year given to one of the clerks of our secretary, for his care of the charts above mentioned, and £80 a year for care of the office papers, will be applied, so that the actual expenses of this new establishment will not exceed £470 per annum.'

From such small beginnings did the Hydrographic Department, or Office as it was then called, take its birth. The 'mass of information' referred to in the Board Minute included the charts and sailing directions compiled by Captain James Cook between the years 1768 and 1776, by Captains George Vancouver and William Bligh; also the surveys executed by Messrs. Murdoch Mackenzie and Graeme Spence, as well as the charts produced by foreign governments and many other authorities. It is not surprising therefore that the twelve years during which Dalrymple was Hydrographer were mainly devoted to arranging documents, compiling charts and engraving the copper plates. That little if any issue was made to the Fleet may be attributed to the small financial provision made for the new establishment, certainly not to lack of diligence—for the only holiday allowed was Christmas Day.

In May 1808 Mr. Dalrymple was invited to resign and was succeeded by Captain Thomas Hurd, R.N.

During Dalrymple's tenure of office there was no organised surveying as it is now understood, and it will perhaps have been noted that the Board Minute of August 12, 1795, contained no instructions regarding the prosecution of surveys, whether at home or abroad. But Captain Cook had already shown the way, and by his accuracy and attention to detail had for all time set an ideal

which it has been the ambition of later generations to live up to. Cook was a remarkable man in every way, and his example inspired others, among them Captain Matthew Flinders, in the *Reliance*, who may be said to have been the first naval surveyor employed abroad under the auspices of the Hydrographic Office. This does not imply that there was no hydrographic surveying done at all during this time; on the contrary, a great deal of work was being carried out by navigators the world over, La Pérouse, Malaspina, D'Entrecasteaux, Beautemps Beaupré, Baron Humboldt and Lisiansky being perhaps the best known and most able. The importance of the surveys in the Far East executed by Captain James Horsburgh in 1796–1812 cannot be exaggerated, nor should the work of Commander W. R. Broughton on the coasts of China and Japan be overlooked.

Since Dalrymple's time, the post of Hydrographer has been held by naval officers who have specialised in surveying; their term of office has varied considerably, but in the long period from 1808 to 1945 there were only thirteen altogether, an average of nearly eleven years for each holder.

In reviewing the work done during the last 170 years it will be convenient to record the activities of the principal surveyors during the term of office of each Hydrographer; thus not only the progress of hydrography but also the labours of some of the chief contributors to it will be clearly set out and appreciated.

Captain Hurd held the post of Hydrographer from 1808 to 1823 and under his guidance the status of the Department was greatly improved. The staff increased and the surveying service of the Navy, almost non-existent when he was first appointed, became merged with the Hydrographic Department and came under the control and supervision of one recognised chief, who was responsible to the Board for the execution of surveys and for the regular supply of charts and other navigational material to the Fleet.

Hurd's major contribution in practical work was his detailed survey of Bermuda, a task which occupied him for nearly nine years and is rightly regarded as a pattern of what a large-scale survey should be. The originals are carefully preserved, and are even now the authority for the intricacies of the surrounding barrier reefs and other details. It is of interest to recount that more than a century later consideration was given to the possibility of developing an entrance to Grassy Bay, Bermuda, through the northern portion of the outer barrier of coral reef, and that air photographs were obtained over a considerable portion of the reef. A comparison made of these photographs and Hurd's original survey proved conclusively the meticulous accuracy of the old work, and it is conceivable that Hurd used some form of water-glass, for the outline of the coral below the surface is shown in great detail and exactness. This could not have been delineated by the use of the lead alone, and is probably the only survey of its size in existence which shows such definite particulars of under-water features.

In 1814 two surveying ships appear for the first time in the official Navy List; by 1818 these had been increased to eight, employed variously in Home waters, Sicily, Newfoundland, the West Indies and even the Canadian lakes.

In 1823, when Captain Hurd died, there were twelve vessels employed on surveying duties; in addition to the localities already referred to, work was in progress on the coasts of Africa and Western Australia and in the Mediterranean. Among those who were in charge of surveys at this time were W. H. Smyth, Francis Beaufort, W. F. W. Owen, H. W. Bayfield, A. T. E. Vidal, and F. Bullock; all of them contributed greatly to the advancement of hydrography, and their names are closely associated with the coasts on which they worked.

One of the last official acts performed by Captain Hurd was to obtain the sanction of the Board to his proposal to make the Admiralty charts available for the use of the Mercantile Marine and the public; there was a good deal of opposition, but Hurd overcame it, and this wise measure has been continued and is of inestimable benefit to seamen all the world over.

It is not possible to give details of the surveys carried out by all the ships so employed, but in some cases the work done was of so remarkable a character that it cannot be entirely omitted. Hydrographic surveying has always been an arduous task, requiring genuine enthusiasm, the power of endurance, patience and application; it also requires the ability to inspire those less interested, so that hard work and drudgery should not adversely affect morale and hinder the acquisition of data required to complete the drawing of the charts and the compilation of the sailing directions so necessary to the navigator. Since about the year 1870 it has been customary for officers to volunteer for surveying, and to devote the whole of their service career to that branch of the Navy. Prior to that time it frequently happened that an officer did one or two commissions in a surveying ship, and then reverted to the general service; or he might be selected when a senior officer for a special piece of work. In the early days of the surveying service this was perhaps inevitable, and it is a tribute to Hurd's judgment that so many first-class officers were attracted to and employed in that service during his time as Hydrographer.

Rear-Admiral Sir William E. Parry became Hydrographer in 1823. With two breaks, during which he made voyages to the Arctic, he served in that capacity until 1829, when he resigned as a protest against the way in which the Hydrographic Department was being treated. The then Secretary of the Admiralty viewed with concern the growing expense of the office and the costs of the surveys, and succeeded in persuading the Board of Admiralty that correct and up-to-date charts and sailing directions were an unnecessary luxury. It is not to be wondered at that hydrography made poor progress at this time, and the marvel is that the Department was kept alive, for the staff consisted of one assistant, three draughtsmen and a clerk, though the number of published charts had already risen to nearly one thousand.

Rear-Admiral SIR FRANCIS BEAUFORT was appointed Hydrographer in 1829 at the age of fifty-five, and remained so full of energy and enthusiasm that he held the post for twenty-five years. His profound knowledge, devoted application, ability and experience raised the Department and the surveying service to heights which his precedessors had scarcely dreamed of, and the office became the model on which foreign governments shaped their hydrographic services. He was held in admiration and affection by the band of officers who served under him, and its speaks well for their loyalty and faith in his judgment that there was never any question of appointing a younger man to the post until Beaufort's health began to suffer from the demands made by the heavy task.

During his long term of office he established the rule, still maintained, that no chart or other document was ever allowed to be published until it had undergone the Hydrographer's personal examination; there is no doubt that this critical revision acts as an incentive to the Department, and is largely responsible for the remarkable degree of accuracy for which the hydrographical publications of the Admiralty are famed. It is no exaggeration to say that Beaufort laid the foundation-stones of the Department and the surveying service afloat, that the organisation which he initiated has stood the test of time, and that it is in essential respects much the same as when he relinquished his post.

He could be severe enough on occasion, as his letters show, and was no respecter of persons as such. He required no more than what he himself gave, but his standard was high, and he considered that his officers should devote the whole of their energy to the prosecution of the surveys of which they were in charge; he was quite frankly not interested in what is sometimes called 'showing the flag'. His approbation was eagerly sought and, when deserved, wholeheartedly given; with such men as Belcher, Vidal, Denham, Spratt, Barnett, Bate and Owen Stanley serving under him, it is not surprising that a vast amount of work was done both at home and abroad, and that its quality was extremely high. The office staff, too, had to be organised and directed and lifted out of the rut, but it was not until 1831 that the Hydrographic Office came into being as a separate Admiralty department, framing its own estimates and programmes of work.

Among the surveys in active prosecution during Beaufort's Hydrographership were the following: the British Isles, Mediterranean, west coast of Africa, West Indies, Australia, New Zealand, China Sea, South America and the Gulf of St. Lawrence; there were many others, and indeed Beaufort conceived it to be his duty to endeavour to chart the seas of all the world. Other governments were not so particular about territorial waters as they now are, and in many if not all cases the surveys undertaken by the British Navy in foreign waters were welcomed.

Rear-Admiral JOHN WASHINGTON succeeded Sir Francis Beaufort in 1855

and held office for eight years; like his illustrious predecessor he had not done a great deal of surveying in the field, but he had been associated closely with the Hydrographic Department, and his enthusiasm and energy found ample scope at the Admiralty. It would have been difficult to follow Beaufort but for the changes which progress entails, and these no doubt helped Washington, though his tenure of the post cannot have been very easy. In 1863 H.M.S. *Orpheus* was lost on the Manukau bar in New Zealand, and it appeared at first that some blame for the disaster rested with the Hydrographic Department; this was proved later not to be the case, but it so weighed on Rear-Admiral Washington that he broke down mentally, became the victim of despondency and ill-health, and died in the same year.

Much of the surveying done during the years 1855–1863 was carried out in hired vessels. There seem to have been two reasons for this: the scarcity of suitable service craft, due possibly to the Crimea War, and the difficulty in getting sufficient money made available in the estimates. The surveys at home and in foreign waters were continued, and in addition work was begun in Japan, the Fiji Islands, Vancouver Island and the River Plate, while the Russian war made it possible to execute important surveys in the Baltic.

It has been written that 'a state of war had always proved to be *the* opportunity of the British Hydrographic Department'. The truth of this remark was illustrated during the wars in Victorian days, as also during the world wars of 1914–1918 and 1939–1945.

There is no doubt that the words were used in the sense that hostilities provide opportunities for surveying foreign coasts and ports which are not present in time of peace; but it is equally true to say that it is in time of war that an officer of the surveying service is brought most closely in touch and in competition with his brother officers of the general service. In such times his ability and initiative are tested to the full, and the long list of honours and awards to surveying personnel is an eloquent testimony to the appreciation which their work has received from Commanders-in-Chief afloat.

Rear-Admiral George H. Richards, 1863–1874, was almost exclusively employed on surveying duties during the whole of his career at sea. His major work was in British Columbia and Vancouver Island, but he surveyed also in the Pacific, China, South America and New Zealand, and was one of the many distinguished officers who joined in the search for the Arctic explorer Franklin in 1852. During his eleven years at the Admiralty, Richards carried through many reforms; the examination of masters and other navigating officers in pilotage, formerly conducted by Trinity House, was transferred to the Hydrographic Department, and this, the old 'Staffy' branch as it was generally called,* became gradually amalgamated with the executive or deck officers' branch. The steady increase in the volume of work coming into the office, and

* In later years, the Senior officers of the branch were known as Staff Commanders and Staff Captains.

the insistent call for greater output, coupled with the abolition of the Indian Navy in 1862, clearly showed the need for an expansion of the office staff, and the Board approving, a considerable increase was made to both the naval and civil establishments.

The crowning achievement of Richards's career was the fitting-out and launching of the *Challenger* Expedition under Captain, afterwards Admiral, Sir George Nares; there is no doubt that he was the prime mover in this great scientific expedition, probably the most important oceanographical survey which has ever been undertaken.

In spite of a difficulty which developed in securing officers for surveying, the practical work was carried on with great vigour in many parts of the world. China, Nova Scotia, New Zealand, the Mediterranean, Australia, as well as deep-sea sounding, received attention, and no surveying ship on passage was ever permitted to make a voyage without at the same time taking every opportunity to improve the existing charts and other publications. These diversions often added many weeks to a voyage; the search for a reported shoal might well be prosecuted by a succession of ships passing over the same track, until the danger was located and the report confirmed or its existence disproved. It should be noted that nearly all the work of the early surveyors was carried out in sailing vessels, and that they had no steam boats to help them out in execution of the inshore portions of the survey; they seem, however, to have been possessed of a sixth sense, and although from time to time uncharted rocks and shoals are located in modern re-surveys it is true to say that seldom was any important danger missed by the 'old masters' where a survey was made in any detail, or in much-frequented waters.

It should be emphasised that what constitutes a danger to the present-day deep-draught ship was safe water to the vessels of the nineteenth century. In other words, whereas the 3-fathom line (a fathom equals 6 feet) was then the recognised danger-line, it is now the 6-fathom contour.

Captain Sir Frederick J. O. Evans, 1874–1884, joined the Navy in 1828 and started his surveying career seven years later, when he was employed in British Honduras. Subsequently his surveying appointments took him to the Mediterranean, New Guinea, Australia and New Zealand and in 1854 he served in the *Lightning* in the Baltic during the war with Russia. In 1855 he became Superintendent of the Compass Department of the Admiralty, and continued in this office until 1865, when he became Chief Naval Assistant to the Hydrographer, a post which he held for nine years.

Under his special and personal supervision a series of charts showing the prevailing winds and currents in the Atlantic, Pacific and Indian Oceans were produced and published. These were the first of their kind, and a form of publication of great value to seamen.

During Evans's term of office the prosecution of surveys at home and abroad made steady progress, the *Challenger* Expedition was successfully concluded,

and the survey of Victoria and South Australia was completed. Elsewhere, the surveys in the China Sea and Coral Sea were resumed, and fresh work was started in the Fiji Islands and in the Red Sea; work in the Mediterranean and on the east coast of Africa was temporarily suspended. An expedition was organised and led by Captain Sir G. S. Nares in an attempt to reach the North Pole.

An event of considerable importance to the surveying world occurred in 1882 when H.M.S. *Triton* was launched. This little vessel, the first to be built specially for surveying, was a paddle-wheeler of about 500 tons, and carried a steam whaler in addition to her pulling boats; though ill-suited to the tasks for which she was designed, the *Triton* continued in commission until the outbreak of war in 1914, when she was finally paid off.

Rear-Admiral Sir William J. L. Wharton, 1884–1904, ranks with Sir Francis Beaufort as one of the most outstanding Hydrographers that the Navy has produced; his career both at sea and at the Admiralty was highly distinguished, and his long term of office as Hydrographer enabled him to improve methods of compilation and technical aids to surveying; such aids were becoming ever more important to an already wide-awake band of officers keen to make progress and at the same time to lighten the labour of those who toiled in tropical heat or under arctic conditions.

Wharton himself had experienced the rigours of the Arctic, and in so doing had early lost the use of his right hand; but much of his surveying work was executed in the tropics, and in such widely separated places as the Sea of Marmara, the River Plate, the east coast of Africa, Sicily and the Straits of Magellan.

He took an active part in the affairs of the Royal Society, and did much to encourage scientific work in the Navy, as well as taking a keen interest in the affairs of the Royal Observatory at Greenwich. For more than twenty years he controlled the surveying work afloat and the office work at the Admiralty; the principles laid down by him are adhered to still, and have proved their worth over and over again. Wharton was a man of great charm, and though he could on occasion be severe enough, he was always ready to help in case of difficulty, and his great knowledge was of inestimable value to the service.

So much and so varied was the surveying work done during Wharton's régime that space does not permit a detailed account of it; suffice it to say that wherever British ships could go, there the work of the hydrographic surveyor lay, and in Wharton's time they covered pretty well the whole world in their activities. It is perhaps not appreciated that at least a part of almost every coast in the world has at one time or another been surveyed by ships of the Royal Navy; thus it happens that the earliest reliable charts and sailing directions of the Ægean Islands, Greece, Turkey, China, Japan, the Philippine Islands, Uruguay, Argentina and other coasts and groups of islands are of British origin. This prodigality of exploration and survey is probably partly

responsible for the fact that the Admiralty maintains a stock of charts, compiled and published by the Hydrographic Department, covering the whole of the navigable portion of the world.

Rear-Admiral A. Mostyn Field, 1904–1909, was one of the few, if not the only officer, to obtain full examination marks in Navigation at the Royal Naval College, Greenwich. On promotion to commissioned rank he volunteered for surveying and was kept very fully employed in many parts of the world; his principal surveys while in command were carried out in the Pacific, the coasts of Australia and China, and in British North Borneo. There is no doubt that a long tenure of the post of Hydrographer is to the advantage of the Department and to the surveying service afloat; five years is too short a period for the inauguration of well-considered and progressive policy, neither does it permit of full justice being done at meetings of the various learned societies at which the Hydrographer represents the Admiralty and where his advice and assistance are so frequently asked for. Sir Mostyn Field died in 1950, aged ninety-five.

Rear-Admiral Herbert Purey-Cust, 1909–1914, took up surveying as a young lieutenant, and his service afloat carried him to the same parts of the world as his predecessor, with the addition that he executed surveys on the south and east coasts of Africa and in the Red Sea.

It was the custom from 1884 to 1914 to send junior commanding officers abroad to give them experience and help them to develop initiative, the more senior captains being employed on surveys in Home waters. After the first world war this policy was reversed; it was then considered, with some justification, that junior officers were too inexperienced, and that their training could best be attended to by keeping them in Home waters, where difficult points in the prosecution of a survey could readily be referred to higher authority.

Purey-Cust's period of office was a peaceful time, but since there were signs that war with Germany could not long be staved off, great attention was given to the survey of potential fleet anchorages, in particular Scapa Flow and the harbours and approaches of focal points in the Empire chain of supply bases and dockyard ports. Sir Herbert Purey-Cust died in 1938.

Rear-Admiral Sir John Franklin Parry, 1914–1919, grandson of Sir William E. Parry, the third Hydrographer, became Hydrographer almost immediately after the outbreak of war with Germany, and it was due largely to his genius for organisation that the Department was able to meet the sudden and heavy demands for hydrographical publications of all kinds, and to satisfy the requirements of the Fleet for a great variety of special charts for war purposes.

Parry's principal activities afloat consisted of surveys in Australia and British Columbia, and he turned out a very large quantity of material; his sound judgment in the choice of staff both afloat and at the Admiralty undoubtedly contributed to the success that marked his tenure of the post of

Hydrographer. He developed a remarkable breadth of vision and capacity for work, and was ably seconded by a devoted staff of naval officers and Civil Servants. His relations with hydrographic offices overseas were most cordial, and he did much to foster co-operation and the exchange of information, particularly with France. This led to an exchange of views between Parry and M. Renaud, the French Hydrographer, which culminated in the holding of an International Hydrographic Conference in London in 1920, and ultimately led to the establishment at Monaco of the International Hydrographic Bureau, of which Parry became the first presiding director. He died in 1926.

Vice-Admiral Frederick C. Learmonth, 1919–1924, was one of the most active and energetic surveyors at a time when enthusiasm ran high; his wide experience as an assistant surveyor in many parts of the world and his charge of surveys in the Mediterranean, the west coast of Africa, British Columbia and China eminently fitted him for the post of Hydrographer, to which he brought a wealth of knowledge and a devotion to the service which can seldom have been equalled.

During his term of office he was beset by the problems arising from the cessation of hostilities, the reduction of staff, and efforts to overtake arrears of work accumulated during the war, in addition to those of maintenance of an adequate fleet of surveying ships and the naval personnel to man them. Once these difficulties were overcome the resumption of surveys at home and abroad quickly followed; among others was completed the important survey which led to the building of the Singapore Naval Base, and Learmonth was sent out with an Admiralty committee to report on the feasibility of the scheme. His death occurred in 1941.

Vice-Admiral H. Percy Douglas, 1924–1932, from the early days of his specialising showed a marked aptitude for surveying; he possessed an inventive turn of mind, and the service is indebted to him for the Douglas protractor, the Douglas-Appleyard arcless sextant, and many other aids to navigation, while he also devised the Sea and Swell notation now in general use for meteorological reports.

As an assistant surveyor, Douglas was employed in the Mediterranean, on the west coast of Africa, and in China, British Columbia and Home waters. His only two commands were in China and the West Indies; this paucity of time in actual charge of surveys was due to his selection for staff posts, first at the Admiralty prior to 1914 and then continuously during the first war with Germany, during which he served on the staff of Admiral Sir John de Robeck during the Dardanelles campaign and later with Admiral Keyes at Dover. On the setting up of the Naval Meteorological Service he became its first Director.

Douglas's interests were wide; the introduction of echo-sounding into the service was in great measure due to his enthusiasm and belief in its future; he set about improving the mathematical instruments in use in surveying ships,






1 THE HYDROGRAPHERS OF THE NAVY, 1795–1909

Alexander Dalrymple, F.R.S., 1795–1808

Captain Thomas Hurd, R.N., 1808–1823

Rear-Admiral Sir William E. Parry, KT., F.R.S., 1823–1829

Rear-Admiral Sir Francis Beaufort, K.C.B., D.C.L., F.R.S., 1829–1855

Rear-Admiral John Washington, 1855–1863

Rear-Admiral George H. Richards, C.B., F.R.S., 1863–1874

Captain Sir Frederick J. O. Evans, K.C.B., R.N., F.R.S., 1874–1884

Rear-Admiral Sir William J. L. Wharton, K.C.B., F.R.S., 1884–1904

Rear-Admiral A. Mostyn Field, F.R.S., 1904–1909



2 H.M.S. *Challenger* about 1870

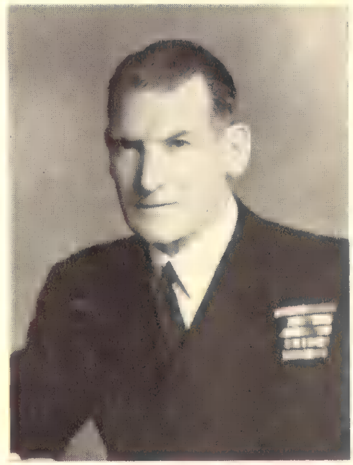
3 H.M.S. *Challenger* in 1946

4 H.M.S. *Vidal* off Gibraltar in 1960. Note the helicopter platform aft

5 H.M.S. *Echo* of the Inshore Survey Squadron off the Goodwins in 1958





6 THE HYDROGRAPHERS OF THE NAVY, 1909–1965

Rear-Admiral Herbert E. Purey-Cust, C.B., 1909–1914

Rear-Admiral Sir John F. Parry, K.C.B., 1914–1919

Vice-Admiral Frederick C. Learmonth, C.B., C.B.E., 1919–1924

Vice-Admiral H. Percy Douglas, C.B., C.M.G., 1924–1932

Vice-Admiral Sir John A. Edgell, K.B.E., C.B., F.R.S., 1932–1945

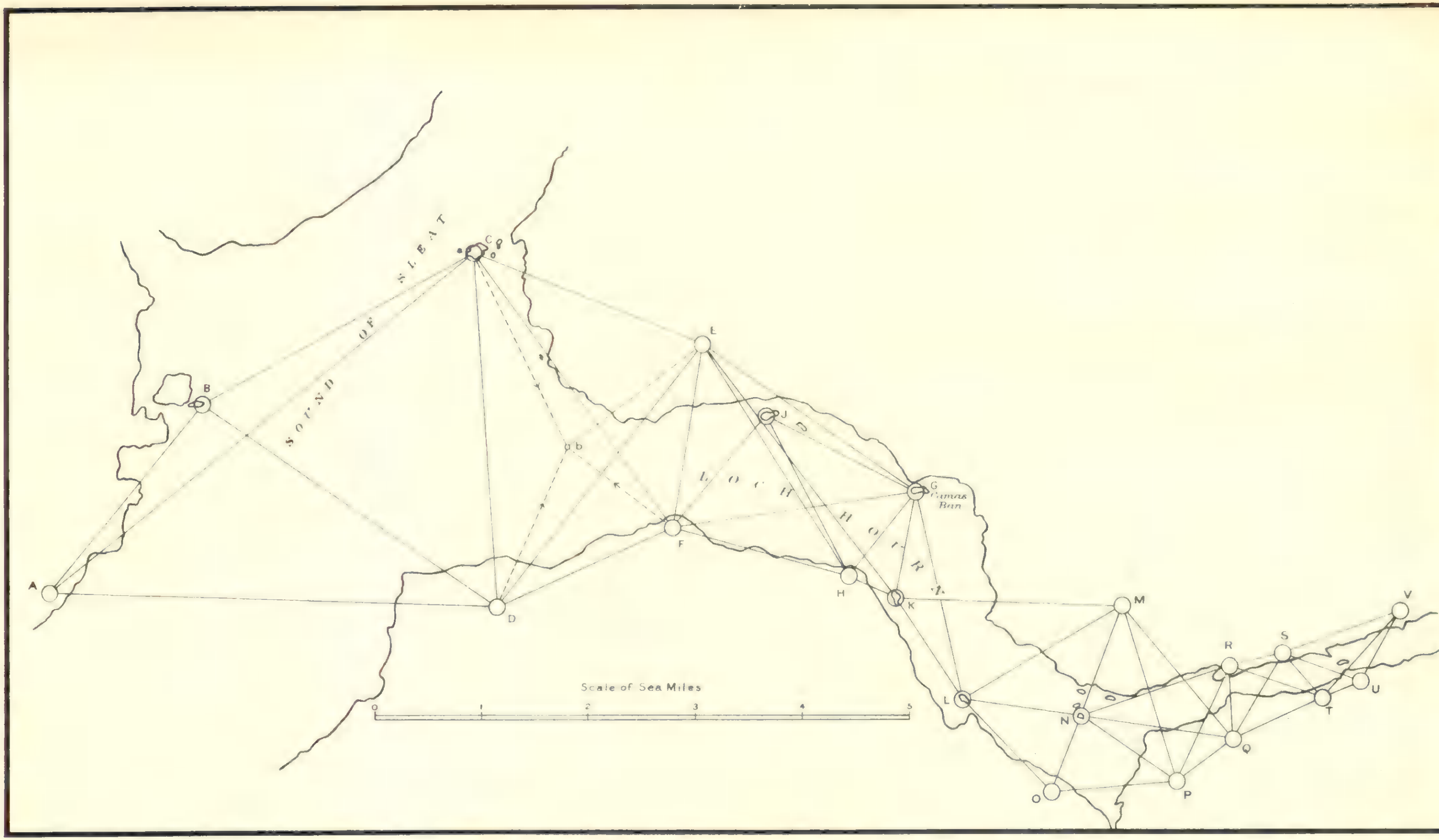
Vice-Admiral Sir A. Guy N. Wyatt K.B.E., C.B., 1945–1950

Vice-Admiral Sir Archibald Day, K.B.E., C.B., D.S.O., 1950–1955

Rear-Admiral K. St. B. Collins, C.B., O.B.E., D.S.C., 1955–1960

Rear-Admiral E. G. Irving, C.B., O.B.E., 1960–





7 AN EXAMPLE OF A SIMPLE TRIANGULATION SCHEME. In this scheme of triangulation (Loch Hourn, on the west coast of Scotland) by Commander R. E. Southern, R.N., the lettered positions are the theodolite stations at which angles were taken to control the survey subsequently made. The position 'b' to which pecked lines are drawn was not included in the main triangulation because it could not be observed at. The base measurement was derived from the Ordnance Survey of Great Britain

8 Hong Kong as seen from the anchorage.
Drawn by Lieutenant L. G. Heath, H.M.S. *Iris*, 1846

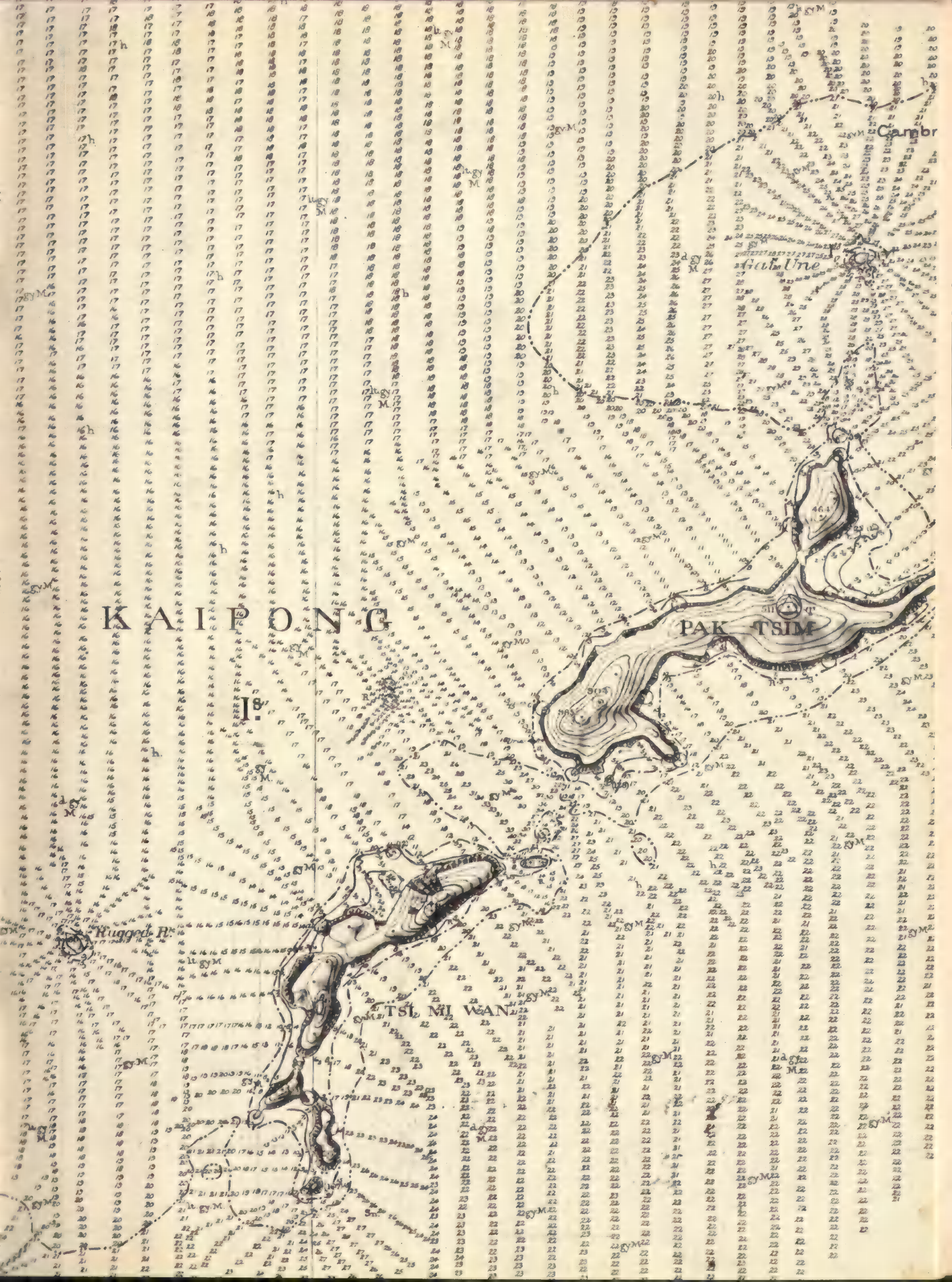
9 Entrance of Crookhaven on the south-west coast of Ireland.
Drawn by Captain The Hon. Foley C. P. Vereker, R.N., 1896

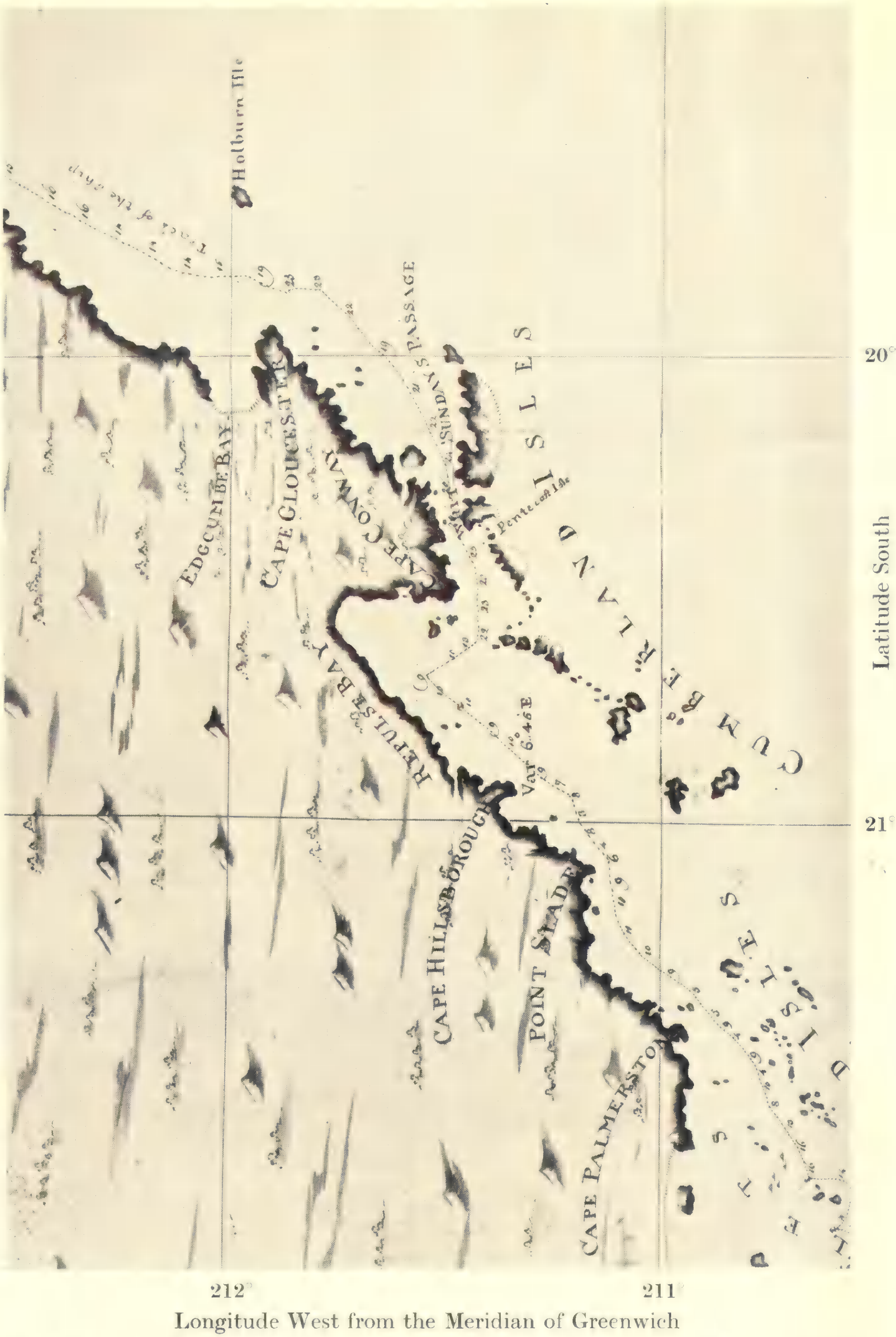
10 A survey party working in the Grenadines, West Indies, 1962

11 KAIPONG ISLANDS OFF THE SOUTH-EAST COAST OF CHINA. This illustration reproduces a portion of a twentieth-century survey, showing the method of sounding out the approaches to a port

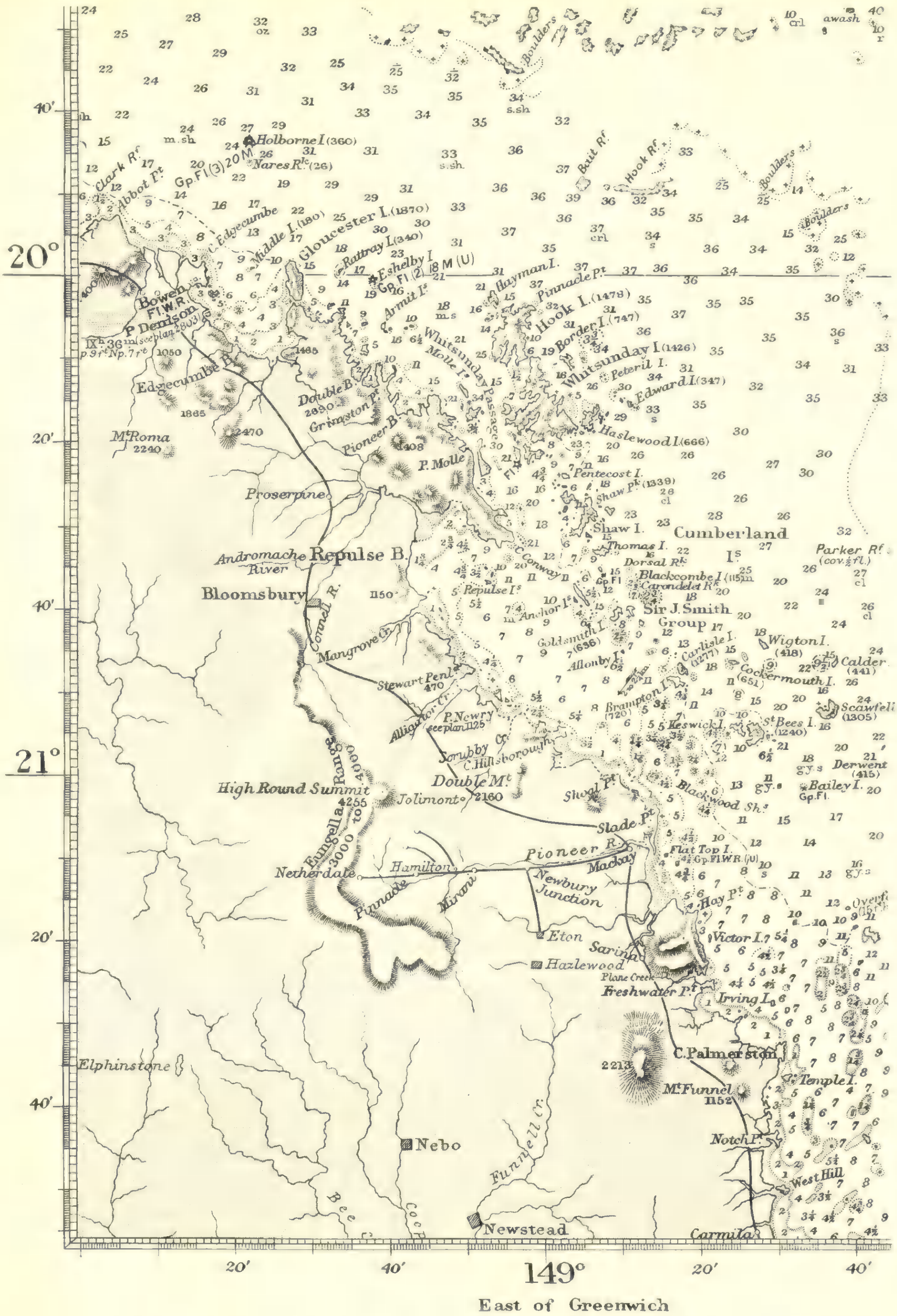
The soundings are in fathoms (those under eleven, in fathoms and feet) and are reduced to the level of mean low water spring tides. Where the soundings appear more numerous it is an indication of a suspected shoal, e.g. Rugged Rk. It is customary to 'star' round isolated rocks and salient points in order to make certain that nothing of danger to the navigator has been missed. Normally lines of soundings are run at right angles to the coast or, in the case of open water, in a direction best suited to the requirements of the survey, the weather, and on occasion the movement of shipping.

The letters which appear close to the soundings are used to indicate the nature of the sea-bed. The full list is given in an Abbreviation Chart published by the Admiralty. In this illustration, the letters employed represent the following: h, *hard bottom*; lt gy M, *light grey mud*; d gy M, *dark grey mud*; R, *rocks*.


KAIPONG
Is.
PAK TSIM
TSI NI WAN
Rugged Rk.
Gau Une
Cambr



12 From a chart of 'part of the Sea Coast of New South Wales, on the east coast of New Holland, by Lieutenant J. Cook, commander of His Majesty's Bark the *Endeavour*, 1770'
(B.M. additional MS. 7085.38 by courtesy of the Trustees of the British Museum)



13 From a modern chart of the Queensland coast and Great Barrier Reef, showing the same coastline as that in Lieutenant (later Captain) James Cook's chart opposite

14 A 10-ft. gravity sea-bed corer being recovered, H.M.S. *Owen*, 1960

providing precision instruments of greatly increased accuracy, and encouraged the study of navigational problems, triangulation and astronomical observations; he was an active member of the Discovery Committee and of numerous scientific bodies.

Admiral Douglas rejoined the Navy in 1939 and died at Dover at the end of that year.

Vice-Admiral SIR JOHN A. EDGELL, 1932–1945, joined the surveying branch in 1902, and participated in surveys in Home waters, British Columbia, China, the Red Sea and Australia before being given command and placed in charge of surveys on the west and south coasts of Africa, the West Indies, Mediterranean, China, Australia and finally the Red Sea and Palestine.

The requirements of surveying afloat were far greater than the small fleet of eight vessels was able to fulfil, and it was with the utmost difficulty that the needs of the Navy and Mercantile Marine were partially met. Those requirements led to the building of six new surveying ships, and would have resulted in an increase in the effective strength but for the outbreak of war in 1939, which put a stop to all surveying activities except such as were required for war purposes. The need being great, more than half the surveying fleet was given up to the general service to augment the number of escorts and minesweepers.

During Edgell's tenure of the post, the Royal Research Ship *Research*, a non-magnetic vessel of about 800 tons displacement, was built for the purpose of determining the magnetic values at sea and for the study of atmospheric electricity. This vessel was built at Dartmouth of teak and brass, and would have sailed on her first voyage early in 1940 but for the commencement of the second world war.

The activities of the Department were concentrated on war work, and the call for hydrographical information was the heaviest that the Department had ever been called upon to meet. The annual production of charts alone rose to over four millions, and demands for them would have been impossible of fulfilment but for the fact that in the four years preceding the war the old-fashioned flat-bed printing machinery had been replaced by the most modern rotary offset plant, greatly increased in actual numbers of machines, and housed in a large new factory. Sir John Edgell died in 1962.

Vice-Admiral SIR GUY WYATT, 1945–1950, joined the Navy in 1906 and the surveying branch in 1918, working in Home waters, Australia, New Zealand, East Africa, West Indies, Mediterranean, Persian Gulf and Labrador. During the second world war he served at the Admiralty, and in command of the *Challenger*.

Vice-Admiral SIR ARCHIBALD DAY, 1950–1955, joined the surveying branch after serving in the first world war as a destroyer officer. He served in H.M. surveying ships *Endeavour*, *Fitzroy*, *Iroquois*, *Ormonde* and *Scott*, and at the Admiralty. While on the staff of the Flag Officer Dover, he planned the routes

used by craft engaged in the Dunkirk evacuation. As Assistant Hydrographer at the Admiralty, he was closely concerned with the preparation of charts for the Allied landings in Sicily and Normandy. He then became Fleet Hydrographic Officer in the East Indies. He commanded the surveying ship *Dalrymple* and, after promotion to Rear-Admiral in 1949, was Flag Officer Commanding British Naval Forces in Germany.

Rear-Admiral K. St. Barbe Collins, 1955–1960, joined the Navy in 1918 and qualified for hydrographic duties while a Sub-Lieutenant in 1925, serving in H.M.S. *Fitzroy*. Thereafter he served in H.M. surveying ships *Beaufort, Herald, Flinders* and *Endeavour*. During the second world war, he commanded in the same service H.M. ships *Scott, Dampier* and *Cook*. In 1954 he was appointed to the new surveying ship *Vidal* when she was engaged on work in the West Indies.

Rear-Admiral E. G. Irving, appointed in 1960, is the present Hydrographer.

In briefly sketching the activities of the Hydrographers who have held the post since 1795 it has not been possible to pay tribute to many other able men who devoted their lives to the business of charting the seas, but something must be said of some of them, if for no other reason than to illustrate their devotion to their calling and the variety of the services which they were called upon to perform. Their names are not household words; some, indeed, have seldom been heard of outside the doors of the Hydrographic Department, but their work lives, and the charts resulting from their labours, are still in many cases in daily use.

George Thomas, Master, R.N., was surveying in Home waters for thirty-six years, 1810–1846.

Rear-Admiral W. H. Smyth will always be associated with the Mediterranean, where his surveys were executed between the years 1813 and 1824. Smyth joined the Navy in 1805, and accepted retirement nineteen years later at the early age of thirty-six with the rank of Captain. He played an important part in establishing the Royal Geographical Society, and may indeed claim to have been the originator of this famous institution; he was also closely connected with the inauguration of the Royal United Service Institution and its Museum. It is of interest to note that Smyth's original surveys of Sicily and southern Italy were made use of in 1940, over a hundred years after they had been completed, when the possibility of effecting a landing on the Sicilian coast was being discussed.

Vice-Admiral W. F. Owen's surveys of the African coasts were made during the years 1822–1826 inclusive. The *Leven* and *Barracouta*, together with the tenders *Heron, Cockburn, Albatross* and *African* worked continuously during five years, though seldom more than three of the vessels were in commission at the same time. The amount of work done and the arduous nature of the surveys can scarcely be fully appreciated in these days. Owen had no such luxuries as steam or motor boats; refrigerators were unknown, and fresh water

had to be obtained as and when possible from the shore. Enough was known, thanks to Captain Cook, about means to combat scurvy, but tropical diseases were usually attributed to swamp vapour, and the mosquito was regarded as being no more dangerous than a gnat. (As recently as the year 1900 it was ordained that His Majesty's ships should scrub decks with fresh water brought off in barges from the shore at Rio de Janeiro, because it was believed that the sea water was contaminated and carried the risk of spreading yellow fever. It is astonishing that this dread disease did not manifest itself among the crews as the direct result of the use of shore water.)

Owen's difficult and arduous task took a heavy toll of his officers and men; fever, no doubt malaria or blackwater, made its appearance early in the commission, and seems to have been prevalent during the whole of the five years which were spent on the east and west coasts of Africa. The stupendous amount of surveying which was done was described by Captain Washington (afterwards Hydrographer) as having been 'drawn and coloured with drops of blood'; Owen lost almost all his original officers and men, and many of those who came out to make good the shortages. He surveyed some 30,000 miles of coast and sent home no fewer than eighty-three charts, the result of his labours. Much of his work is still the basis of some of the Admiralty charts of both sides of Africa, and two of his lieutenants, Vidal and Richard Owen, survived the long five years' commission and continued to undertake surveys during the rest of their naval careers.

Captain Sir John Franklin, so well known as an Arctic explorer, began his surveying career under Matthew Flinders on the east coast of Australia; his three expeditions to the Arctic and the tragic fate which overtook the last of them are a matter of history, as are the efforts to discover the fate of *Erebus* and *Terror*, in which he and his companions set out to try to find the North-West Passage in the year 1845.

Admiral H. W. Bayfield's name is associated very closely with the surveys of the eastern seaboard of Canada and of the Great Lakes. He served in the Dominion for some forty years, mostly in the schooner *Gulnare* and was responsible for the compilation of forty-five charts; much of his work done in 1817–1856 is still in use.

Vice-Admiral A. T. E. Vidal, with Owen in the *Leven* and *Barracouta*, was, as stated above, one of the few officers to survive the five years' survey of Africa, and one would not have expected him to return to the same locality; however, Vidal not only revisited the west coast of Africa and made surveys there during the years 1835–1840, but was also afterwards employed charting the Azores in H.M.S. *Styx* until 1846. Of the accuracy of his work the present writer had ample illustration when ordered to resurvey the coast of Liberia in 1912.

Admiral E. Barnett is remembered through his surveys in the West Indies, where he was almost constantly employed for twenty-two years, seventeen of

which were in command of ships, including nearly eleven years in the *Thunder* in the ranks of lieutenant, commander and captain.

Rear-Admiral R. FitzRoy's surveying career was comparatively brief, lasting only from 1829 to 1836, but was unique in that his only ship was the celebrated *Beagle* in which Charles Darwin was a 'volunteer', geology being his principal interest at the time.

The *Beagle*'s surveys of South America are well known, and FitzRoy's work in the Magellan Straits has been consulted and quoted time and again when territorial water claims have been in dispute between Chile and Argentina.

While in the *Beagle*, and in order to expedite the survey on which he was engaged, FitzRoy hired two small vessels to complete the survey of the Falkland Islands and subsequently purchased a third, as well as refitting the *Beagle* largely at his own expense. His zeal in this connection cost him several thousand pounds, for the Admiralty refused to reimburse him.

In later years FitzRoy became Member of Parliament for Durham and was Governor of New Zealand from 1843 to 1848. Towards the end of his life, which occurred in 1864, he was the first superintendent of the newly formed Meteorological Office of the Board of Trade, and it is due to him that the system of storm warnings came into being.

Rear-Admiral John Lort Stokes was one of FitzRoy's pupils, and joined the *Beagle* as a midshipman in 1825. He remained in her for the South American survey, and during her Australian survey of 1837–1843 he became her Commander. Subsequently, he commanded the *Acheron* in making the first survey of New Zealand, 1847–1851. The *Acheron* was the first steamer employed in a distant survey.

Admiral Sir Edward Belcher, explorer, surveyor, inventor, diplomat and warrior, found time during his twenty-two years' employment as a surveyor to turn out material sufficient for the compilation of forty-five charts. A man of indomitable courage and a fine seaman, he saw active service on the coasts of France, Italy, Algiers, Spain and China and was in command of the expedition which was despatched to the Arctic to search for Franklin in 1852; he was in a sense the stormy petrel of the surveying service of his time, and by tradition at all events a hard man to serve, though it is possible that some of his assistants in the field were not imbued with the same enthusiasm and energy which he himself possessed.

Captain Thomas Graves, Vice-Admiral T. A. B. Spratt, Rear-Admiral A. L. Mansell in H.M. ships *Mastiff*, *Beacon*, *Volage*, *Spitfire* and *Medina*, were all employed in conducting surveys in the Mediterranean; the first-named for ten years, and each of the other two for no less a period than thirty-one years, Spratt from 1832 to 1863, and Mansell from 1835 to 1866. Modern needs have compelled the resurvey of some of the harbours and anchorages covered by this indefatigable trio, but in the main their surveys, particularly those of the Grecian archipelago, are still the authority on which

all charts of the locality are based, and they have well stood the test of time and constant use.

Much could be written about the devotion to duty, the arduous tasks successfully completed and the hardships endured by the men who in times gone by laid the foundation-stones on which British Admiralty charts have risen to a state of perfection unsurpassed by any other seafaring nation, but space does not permit; suffice it to say that later generations have followed in the footsteps of the 'Old Masters' and with better tools have accomplished their tasks in less time but with the same thoroughness. Even at the present time it is no unusual thing for a surveying officer to spend less than one-quarter of his sea time in Home waters, and it is on record that one individual served for three years at home and twenty-two years in foreign waters in one period of twenty-five years.

In recounting the services of some of the giants of old it is most emphatically not intended to belittle the labours of their successors; there is, however, considerable difficulty in describing the surveying activities of one who seldom stayed for very long in any particular part of the world, and after the year 1870 it was only in Home waters that officers were constantly employed for lengthy periods. Enough, however, has been said to show the enthusiasm which prevailed in the early days, and it is only necessary to add that the same spirit is fostered and kept alive in the present generation of hydrographic surveyors.

3. THEN AND NOW

THE change from sail to steam has made an immense difference to the organisation and output of a surveying ship; prior to 1860 it was the rule rather than the exception that these vessels were sailing craft. Gradually, however, auxiliary power (as it was called) came into general use, but it was not until the year 1914 that sail completely disappeared and the whole surveying fleet became entirely dependent on steam.

When one looks back and considers the handicaps under which the pioneers in surveying suffered, it is astonishing that so much accurate and detailed information was obtained and laid down on the charts, that so little of importance was omitted or missed, and that enthusiasm was sustained.

It is the duty of the Hydrographer to advise the Admiralty as to the surveys to be undertaken, and he has to endeavour to balance the claims of the Navy and commerce; at all times, with the small number of ships available, this is a difficult problem. Two hundred years ago it must have been almost impossible to decide which part of the globe was most in need of attention when such large areas were imperfectly known.

From the earliest times it has been the policy to concentrate on definite areas and to endeavour to complete the work in them before moving on. This

is not always possible. In the Mediterranean work can be carried on year in year out almost without intermission, but in other parts of the world—such as India, where the south-west monsoon prohibits surveying from June to November, the west coast of Africa, where the harmattan sets a limit to visibility for months on end, and in the China Sea and West Indies, where the typhoon and hurricane seasons make it inadvisable to allow small ships free movement—surveys have to be arranged to suit climatic conditions, and it is often expedient to employ a vessel during the same year in places as far apart as Trinidad and Labrador; Sierra Leone and Nova Scotia; or England and the Red Sea.

It has already been remarked that a hundred years ago the limits of territorial waters were not so jealously regarded as they now are, and the presence of a British surveying ship was often as welcome as today it would be resented; it is for this reason that so much of the world came to be charted by the officers of the Royal Navy, and that is why to this day, in many places outside the British Empire, general, coastal and even harbour charts bear in the title the statement that the survey was made by one of H.M. ships.

Reference has been made to the handicaps suffered by the early surveyors; the difficulties which they encountered can scarcely be exaggerated. They knew little or nothing about climatic conditions, the preservation of health, the distribution and strength of the ocean currents; and their voyages and movements were all made under sail. Work undertaken in boats had also to be done under sail or by rowing; there were no steam or electric capstans and winches, and everything had to be done by hand, from weighing the anchor to getting a deep-sea sounding of perhaps 2,000 fathoms. The instruments provided were certainly the best procurable; even as late as the beginning of the present century sextants, theodolites, scales and protractors originally obtained for the use of polar expeditions were in general use in surveying ships, and very good they were. But as instruments of precision the theodolites left much to be desired, since they were capable of being read only to the nearest minute of arc.

Broadly speaking, the Hydrographer's instructions to an officer in charge of a survey have changed little since the time of Sir Francis Beaufort; the area to be surveyed is described, and the scale on which the work is to be done is specified. In many cases special warnings are included which have reference to difficulties of landing on open coasts, avoidance of trouble with natives, the health of the crew, and so on. Much latitude is usually allowed to the captain, both in the movements of his ship and in the detailed execution of his instructions; in sailing ship days this was inevitable, as when once she had sailed for her surveying ground it might be months before anything more was heard of her. In present times, with wireless installed in all ships, such latitude is not so necessary, but is none the less given because it engenders a sense of responsibility and encourages initiative.

There is an old saying: 'No surveying day is too long'. To the real enthusiast this is no doubt true; it is the usual custom to start work at seven in the morning, and so far as the officers are concerned this may well be continued until eleven o'clock at night. In a well-organised surveying ship it is a matter of routine for the ship to get under way and the boats, sometimes as many as eight of them, to leave the ship at seven; normally the ship will anchor at 6 p.m., and the boats will rejoin her and be hoisted and prepared for the next day's labours. A brief outline of what is involved in the survey of a completely uncharted locality will show the varied nature of such an undertaking.

On arriving at the scene of operations one of the first things necessary is to find a secure anchorage. This is done either by sending in the boats to make a rapid preliminary survey, or by despatching them to sound ahead of the ship. Having come to anchor and taken stock of the surroundings, the officer in charge usually sends parties away to examine the whole area with a view to scheming a triangulation which will cover it with the least possible delay. Much depends on the nature of the terrain; in tropical country, where there is dense jungle, or in places where forests clothe the hill-tops, it is often necessary to fell timber and clear some of the hills. In the long run, provided the stations are judiciously selected, this preliminary work saves time, and moreover contributes to the rigidity of the triangulation as a whole.

The selection of a suitable locality on which to measure a base is of the first importance; it must be level and if possible straight. Bases vary in length according to the magnitude of the work, but it is seldom possible or necessary to exceed 5,000 feet. A base is measured with a special steel tape and the mean of a number of measurements is accepted as the correct distance between the two base stations. The various measurements do not ordinarily differ by more than a fraction of an inch unless, as sometimes happens, part of the base is under water.

The base measurement having been completed, the triangulation proper is undertaken, and a system of quadrilaterals and polygons made up of well-conditioned triangles emerge from the network of trigonometrical stations which have been marked and from which theodolite angles have been taken. A typical triangulation scheme is shown on Plate 7. On completion of the triangulation the main stations used in it are plotted on a large sheet of linen-backed paper and subsidiary marks which are required for subsequent work are incorporated. The fixed points thus determined are transferred to field boards which are used by the surveyors either for sounding, coast lining or topography.

At the very beginning of a survey a tide-watching party is established at a convenient position, and the rise and fall of the tide recorded day and night at half-hourly intervals; apart from the value of these observations for record purposes (they may later be used to predict the tides of a harbour) they are

required for day-to-day use, to reduce soundings to the level of mean low-water spring tides, the normal Admiralty datum used on charts, and to determine the height of rocks and islands in relation to mean high-water spring tides.

The amount of soundings which can be done in one day by a motor boat depends on the weather, and to a lesser degree on the depth of water. All work of this nature is now done by echo-sounding, and a skilful surveyor will turn out an immense amount of work in a working day of some ten hours. In earlier times, when soundings below 12 fathoms were obtained with leadline, the physical strain on the leadsman was very heavy; when the small boat sounding machine was brought into use progress was slowed up by the necessity to stop so that soundings should be correctly taken. The marked changes which have occurred in the last forty years can best be illustrated by a comparison of output; using the leadline, 25 miles of sounding on a 3-inch scale would have been considered a good day's work, but with echo-sounding apparatus between 40 and 50 miles has become a commonplace.

While the boats are working in the shallower water, the ship is usually employed in sounding in the approach to an anchorage or off the coast; in present times it is not unusual that ship and boats combined will accomplish more than 150 miles of sounding in a day. The actual area covered depends on the closeness of the lines of soundings and this in its turn depends on the nature of the sea-bed; where the bottom is uneven, it is obvious that soundings must be very closely done if all possible dangers are to be located.

The delineation of the coastline is done with great care, and in general it is traversed on foot throughout; much depends on the accuracy of this work, not only because of its future use by navigators, but also because the resulting chart may be consulted when planning warlike operations, or may be put in as evidence in a court of law which is dealing with a wreck or other marine casualty. It is seldom that the surveyor afloat is called upon to make a detailed topographical survey; it has been done in war-time, and in 1916 a military force without adequate maps was provided by one of His Majesty's surveying ships with a number of accurate gridded maps of their position, all drawn by hand; but as a rule where there is no land survey available, it is sufficient for the seaman if the summits of the hills are fixed and the topography indicated by form lines which show the character and general appearance of the land. Sketches of headlands, of the approaches to harbours, leading lines and clearing marks are embodied in the sailing directions or 'Pilots', and sometimes appear on the published charts. It is not given to all surveyors to be artists, and the pictorial merits of views vary a great deal; very few can compare with those of the coasts of the British Isles, specially made by Captain the Hon. Foley Vereker, R.N., in the latter part of the nineteenth century, which must be well known to countless numbers of seamen the world over. The geodetic control of a survey is provided by the triangulation, and if this is satisfactorily

connected to a position which has been accurately determined astronomically there will be no need to obtain a special geographical position; more often than not, however, in the localities in which the surveyor is employed it is necessary to obtain observations of the heavenly bodies at selected places in the survey and connect them with some station, possibly remote from the scene of operations, whose position is already established.

Until comparatively recently, the geographical position of a triangulation station was almost invariably determined by a meridian distance for longitude and observations of a number of stars north and south of the position, for latitude; the instruments used were an 8-inch sextant, artificial horizon and chronometer watch or pocket chronometer. An accurate meridian distance depended not only on the quality of the observations for equal altitudes of the sun, but also on the regular behaviour of the large number of chronometers carried, time being the essence of the problem and the longitude finally accepted being referred to the Greenwich meridian. It is difficult to make a definite pronouncement on the degree of accuracy obtained by the meridian distance method, but it is probably true to say that most results were not in error to the extent of more than three seconds of arc.

Observations for latitude, being less dependent on time, were usually accurate to within one second of arc, and the care necessary and labour involved in preparing and carrying out a programme of such work was well repaid by the results. Normally, a full star programme commenced at dusk and continued until daybreak; provided the sky was clear, seven or eight good pairs of stars involving as many as 400 contacts in the artificial horizon were obtained. (Observations for latitude are taken when stars of suitable altitude are near the meridian, either north or south of the observer. It is almost impossible to depend on observing the maximum altitude, and for this reason a series of observations are taken for a few minutes before and after this occurs.)

The sextant has been replaced by the modern astrolabe for astronomical work on shore, and this instrument, combined with the absolute accuracy of the wireless time signals sent out from the Royal Greenwich Observatory, Herstmonceux, has not only reduced the work of the surveyor in the field but greatly improved the reliability of the results. The prismatic astrolabe has a telescope fixed at an angle of 45°, below which is a small mercury bath. Suitable stars of the necessary elevation are selected in the four quadrants, north-east, south-west, etc., and the passage of the stars across the stadia lines in the telescope and their contact with the reflected images are observed and times are recorded on a chronograph; the results are plotted in the form of position lines and, under good conditions, provide the latitude and longitude of a station with a degree of accuracy unobtainable by the old sextant method.

Horizontal tidal movements are of much concern to the surveyor, and hourly measurements are invariably made whenever the ship is at anchor, as well as at selected positions in the area of the survey. Time does not always

permit the study of tidal streams to the full extent desirable, but their importance has been clearly demonstrated in recent years, and there is no doubt that close attention will be given to them in the future.

In September 1939 a tidal stream survey, both surface and sub-surface, of the waters around the British Isles was nearing completion, having been in progress for more than four years; this work was designed to show the direction and rate of the main tidal streams at every hour of the tide, and referred to Dover as the standard port. The French and Dutch hydrographic services collaborated, and the resulting atlas of tidal streams of the British Isles is undoubtedly the most reliable publication of its kind which has been produced. It must not be thought that this atlas provides the answer to every problem of the kind with which it deals; in narrow waters, the approaches to harbours, estuaries, and so on, the tidal streams are often influenced by local conditions; where this is the case all available information is given in the chart or in the Pilots.

When all is said and done, the principal object of the hydrographical surveyor is to obtain and put on paper the depth of water, and a survey can best be judged by the quality of the sounding carried out. It is not enough to run lines of soundings at right angles to a coast or across a shoal or bank; every sounding must be scrutinised by the officer in charge of the survey, and the smallest indication of a shoal usually leads to a closer examination of the area under suspicion. Only thus can the high repute of Admiralty charts be maintained, and although only a small proportion of the soundings are actually used on the published chart (a greater number would confuse the user) the originals are preserved in the archives of the Hydrographic Department and are always available for consultation.

Once a year, and for a period of three months, surveying ships repair to one of the dockyard ports to refit and to draw the charts of the season's work; the refit is usually fairly extensive, since ship and boats are ordinarily under way every day except Sunday during the season, and the wear and tear is heavy.

Preparations for drawing the fair charts are made concurrently with the progress of the survey. In addition to the field boards, a large cloth tracing called the Collector is compiled; this embraces all the work from whatever source. Numerous smaller paper tracings are also made, separate ones for soundings, coastline, low-water rocks, topography and any special searches for rocks, wrecks, etc., which may have been required; these smaller tracings are used to transfer the work to the fair charts which are drawn by the surveying staff—officers, petty officers and men, who are qualified to undertake the work. Much of the drawing work is mechanical rather than artistic, but there is ample scope for the artist and among the 100,000 or so originals in the Admiralty there are many beautiful charts on which the judicious use of colour washes has brought out the salient features and made the task of the cartographer both easier and more interesting.

On the completion of the fair charts each one is checked by a colleague of the draughtsman for errors or omissions, and after a final drastic scrutiny by the Captain is sent to the Admiralty, together with the scheme of triangulation and its tabulated results, the sailing directions, tidal data and astronomical observations. An annual report of progress is also sent to the Hydrographer, which includes recommendations for future surveys, the result of inquiry and investigation by the officer in charge or of some request from the Naval Commander-in-Chief or Chamber of Commerce.

On receipt of the fair charts of a season's work at the Admiralty the material is first catalogued and then, together with the existing chart of the same area, is laid before the Hydrographer, who decides what use is to be made of it, whether a completely new chart or series of charts is to be schemed, or if the existing chart when corrected and brought up to date will suffice for future needs.

The scheming of a series of charts is often a matter of considerable difficulty, for while it is desirable that they should all be on the same natural scale, it may be equally necessary to include some feature of the land, or an isolated shoal or pinnacle rock, which owing to the need to restrict the size of the chart cannot be included; for these reasons many of the older charts of a series are on noticeably different scales, an inconvenient arrangement which adds to the work of navigator and cartographer alike.

The standard size of a chart is about 38 inches × 25 inches. An extension in the length is often a way out of the difficulty of including some important feature; this is acceptable, but an increase in the width, involving as it does a double fold, makes the chart unwielding and adds to the difficulty of the user while at the same time it is liable to introduce distortion.

The modern practice is to scheme coastal charts on a scale of 1:100,000 or 1:200,000, depending on the quality of the original survey, the intricacy of the navigation, and the volume of shipping likely to use the charts. This scheming is sometimes done before the survey is put in hand, and in such cases the scale can be adjusted to meet the requirements outlined above. A typical case of this kind is the re-survey of New Zealand; the scheme was drawn up before the survey was commenced, and when completed the Dominion will be covered by a set of coastal charts all on the same scale.

The scale having been decided on, all material connected with the locality to be charted is collected and examined by the cartographer who is to compile the chart. The blending of old and new surveys is often a matter of much difficulty; so, too, is the connection of material which has been made available from different sources. Old original surveys are compared with the new work, and from beginning to end of the compilation checking and verification go on uninterruptedly. On completion of the compilation drawing the chart is sent to the engraver, who engraves the work on a copper plate. In earlier days all engraving was done by outside firms, but for the last forty years the work has

been carried out by the Admiralty craftsmen. Proofs from the plate are sent to the cartographer at various stages, and on receipt of the final proof the chart goes the round of all branches of the Hydrographic Department and is brought completely up to date in every particular. After a final scrutiny by the Hydrographer it is given a date of publication, is transferred to zinc for rapidity of printing and thereafter published, supplied to the Fleet, and placed on sale.

Concurrently with the production of a chart, the sailing directions are brought up to date and if necessary a supplement to the existing volume is printed; all tidal information is overhauled, and the lights and buoys are checked. The chart is now incorporated in the four thousand or so forming the collection of Admiralty charts which are on issue, and at once becomes liable to correction from day to day by Notices to Mariners, of which over two thousand are published each year.

About eighty volumes of Sailing Directions are maintained and new editions are published at suitable intervals when the available information renders it necessary. Their state of accuracy is assured by the free issue of supplements published either annually or biannually, and by the information promulgated in the Admiralty Notices to Mariners. The Light Lists, of which there are twelve volumes, are similarly kept up to date.

The Tide Tables have within recent years been greatly improved, and the number of large ports for which predictions are calculated has been increased. Predictions are provided on a repayment basis by the Liverpool Observatory and Tidal Institute; for such ports and anchorages as are not included, the Admiralty method of predicting tides provides a simple and accurate means for obtaining the information required.

In a pamphlet of this kind it is not possible to enlarge on the activities of all branches of the Hydrographic Department, but it should be mentioned that oceanography is becoming of increasing importance; its bearing, not only on navigation but also on the performance and efficiency of the Fleet in time of war, has been amply demonstrated and is fully appreciated.

The production and supplies branches are charged with the duty of engraving, lithographic drawing, photography, printing and the issue to the Fleet of all hydrographic material necessary for the safe navigation of H.M. ships. Similarly, the Merchant Navy is provided for by supplies sent to the various Admiralty chart agents for sale in the principal ports of the world. Foreign governments are also supplied on request, and there is a long-standing agreement by all maritime powers by which a free exchange of new material is assured; it is from this material that the Admiralty charts of foreign waters are nowadays chiefly compiled. All seafaring nations except those of the British Commonwealth and the United States have the metre as their unit of measurement for soundings and heights, yet the charts of these two nations are in constant request by others.

4. THE WORK OF THE SURVEYOR IN WAR

It would not be right to omit all mention of the activities of the surveyor in time of war: history shows that ever since the value of accurate and detailed surveys has been properly appreciated, the knowledge and skill of the hydrographic surveyor has been made full use of. At the battles of Quiberon Bay (1759) and Copenhagen (1801) soundings had to be taken under fire before the ships could attack; so, too, in later years, in the Baltic and Crimea during the Russian war, in the rivers of China, and in the first and second world wars, there was a persistent demand for surveys, information and special charts for war purposes.

As in 1914, so in 1939, on the outbreak of war the number of surveying ships in commission was drastically reduced, and those abroad were ordered home. As many surveyors as could be spared were appointed to ships as navigators, and some of the senior officers were put on the staffs of the flag officers afloat.

So far as surveying is concerned, perhaps the centre of activity in the first world war was in the Ægean, where the many and varied demands made on the surveyor were made easier by the authority which was given to print and issue charts, etc., locally. This entailed the despatch from England of a self-contained printing and production unit which amply justified its formation and rendered signal service from the time of the landings in Gallipoli to the end of the campaign in eastern Europe. It is believed to have been the first chart-printing outfit ever placed on board a surveying ship; the first chart, of Aliki Bay, was printed in H.M.S. *Endeavour* in September or October 1915. The numerous charts, plans, diagrams and devices brought into operation were of the greatest value in furthering the successful conduct of the war in this region; so, too, were the surveys carried out in the Cameroons and on the Rufiji River (in what is now Tanzania). At home, maintenance surveys were continued to ensure the safety of shipping, especially on the south and east coasts of England, while the laying of heavy minefields—such as the Dover barrage and that in the North Sea—were based on the accurate positioning determined and buoyed by the surveyor.

The experiences of the first world war were taken to heart, and the need for sufficient surveying ships in full commission in war was fully appreciated, but in 1939 the shortage of small craft for escort and other duties was so acute that is was impossible to implement this policy in its entirety. Actually, the shortage of vessels suitable for surveying persisted throughout the war, and all kinds of makeshifts were indulged in; for instance, during the later stages on the east coast of Italy a small survey unit accomplished its work with a 12-foot motor boat which was transported from harbour to harbour by an Army lorry.

The second world war made even heavier demands on the surveyor than the

first; assistance was given in minelaying, especially in connection with the minefields in the Dover area and between Iceland and Scotland, where the need for extreme accuracy in position was of particular importance. Surveys were made for Fleet purposes in Iceland, the Faeroes, Gambia, New Guinea, the Red Sea, India, Australia, Fiji Islands, Malaya, and numerous other places, including after the occupation of French territory surveys of the region in which a landing was contemplated. This work was done under difficult climatic conditions; and when, later on, the landings in North Africa, Sicily, Italy and France were accomplished, much of it was done under fire and the constant menace of mines.

An important item in the duties assigned to the surveyor was the resurvey of ports occupied by the Allies, and it is true to say that as the Army went in to occupy on the land side, the surveyor came in from seaward and commenced his resurvey of the port, locating sunken wrecks (there were over a hundred at Tripoli), concrete and other obstructions, and generally checking-up harbour conditions.

During the operations on the coast of France five surveying units were engaged on D-Day and subsequently in siting the positions for sinking the block ships and 'phoenixes' (huge concrete structures built in England, towed to France and then sunk and used as breakwaters for the artificial harbours), and in sounding, buoying and marking wrecks off the coast. As the Army advanced work was possible in Dieppe, Cherbourg, Boulogne, Calais, Havre and Antwerp; all these ports were rapidly resurveyed and the results published without delay.

That the gallantry and labour of the surveyors afloat were fully recognised by the various Commanders-in-Chief is amply shown by the numerous honours and awards which they gained; no fewer than forty-eight decorations and thirty-four mentions in despatches were gazetted between 1939 and 1945, although the entire officer personnel available for sea service never exceeded 100 in number. This is a record of which any branch of the Service would be proud. It must be a satisfaction to all connected with the Hydrographic Department that their work was always thorough; there could scarcely be higher praise than the statement that it was up to the standard set by their predecessors.

5. SEA SURVEYS, 1948–1965

By Lieutenant-Commander P. B. Beazley, Royal Navy

SINCE the preceding chapters were written many developments have taken place in the fields of Hydrographical Surveying and of Oceanography, and the latter science has become of increasing importance, as the late Admiral Edgell predicted. However, despite the accelerating rate of development in all

technical fields, which has affected surveyors no less than others, the basic requirements for a survey have remained unaltered, as have the principles employed in their fulfilment.

Perhaps, as one would expect, the most dramatic changes have been wrought by the rapid advances in the science of electronics. Seventeen years ago radar was giving the surveyor, for the first time, the means of obtaining an accurate position even when out of sight of land or in poor visibility, but he was still restricted to off-shore distances of less than twenty miles unless he laid floating beacons to extend his control seawards. Nowadays an accurate position can be obtained more than a hundred miles off-shore, and within a few years the use of satellite navigation and very low frequency hyperbolic fixing devices will permit of such accurate position fixing anywhere in the world's oceans. Furthermore, the developments in echo-sounders have also provided the means of obtaining accurate depths in even the deepest parts of the ocean. Not only have these advances extended the possibilities for straightforward surveying; they have also greatly increased the precision and usefulness of oceanographic data.

Similar developments have taken place with other techniques. The mapping of almost impenetrable coastlines and terrains is now comparatively simple, using both aerial photography and the tellurometer distance measuring device —another piece of electronics which has also made the tedious and time-consuming task of base measurement by steel tape almost obsolete.

One could continue to enumerate all the many improvements that have been introduced during these years, but it is enough to say that there is no aspect of chart making—from field work to final printing—that has not been affected in some way.

And what of the ships? At the beginning of 1948 the surveying fleet consisted of five small pre-war ships (two of which had never been built as surveying ships), and a number of motor launches suitable for inshore work. That year saw the commissioning of the first of four war-time frigates which had been completed for surveying duties. In 1953 H.M.S. *Vidal*, the first surveying ship to be fitted with a helicopter, and the second H.M. ship ever to have been designed as a surveying vessel, was commissioned. At the same time the ageing H.M.S. *Challenger*, which a year earlier had completed a world oceanographic cruise in emulation of her illustrious predecessor, was paid off.

The first of three inshore survey craft was commissioned in 1957. These 160-ton vessels, which had been built for surveying but had identical hulls and engines to those of an inshore minesweeper, eventually replaced all but two of the remaining war-time launches. In 1964 two larger minesweepers were converted for surveying duties in United Kingdom off-shore waters, and they replaced the last of the pre-war ships. The two remaining motor launches are to be replaced by converted inshore minesweepers in 1965.

All these improvements in equipment, ships and techniques have not, however, reduced the amount of work to be done. It is still true to say that there is no end to the surveyor's work. Although there are no new lands to be discovered there is still a vast area of the underwater surface of the globe which is virtually unexplored. The need for its exploration has grown with the advent of the true and deep diving submarine, the search for mineral wealth under the sea-bed, and the need to use the living resources of the sea efficiently to feed an exploding population. The surveying service of the Royal Navy has recognised this need and has devoted a steadily increasing proportion of its resources to the science of oceanography, and its ships have participated in such co-operative enterprises as the International Indian Ocean Expedition. In December 1964 the first of a new class of three survey/oceanographical ships was launched. These ships will replace the war-time frigates, and they will be equipped with everything needful to carry out oceanographical observations of every type as well as to conduct a normal hydrographic survey.

There are many places where the nature of the sea-bed and the presence of strong tidal streams or currents causes continuous changes in the underwater contours. It has always been necessary to resurvey such areas at intervals, and when they occur in the approaches to major ports such as London these resurveys must be frequent. This requirement has become more urgent with the vast increase in size of modern vessels—particularly oil tankers and ore carriers. In 1948 one of the main approach channels to the Thames was surveyed every other year; by 1964 is was being surveyed every six months.

This increasing size of ships has also made necessary the resurvey of stable areas where, for instance, there is a tendency for sharp pinnacle rocks to occur. Many such areas—the west coast of Scotland is one—were thoroughly sounded by lead and line which might, however, have missed such pinnacles between casts of the lead, but in such cases any rock likely to be dangerous to vessels of that era would have given some surface indication to the experienced surveyor. But pinnacles lying more than thirty feet below the surface are dangerous to modern ships, and do not betray their presence to even the most experienced eye. Such hazards can be located with more certainty using modern echo-sounding and sonar equipment.

The search for oil and the development of new nations have both made their demands upon the surveyor. Since the war, and in response to the needs of the oil companies and the nation, the whole of the southern half of the Persian Gulf has been almost completely resurveyed on a scale and to a detail suited to modern needs. This has also enabled new ports to be opened up. Other areas where similar work has been undertaken to suit the varying economic needs of the territories include Trinidad, British Guiana, Malaya, Borneo, British Solomon Islands, and Fiji.

But that is not all that the Hydrographic Department has achieved. Worthy of special mention is the co-operation and exchange with Commonwealth

countries which has resulted in a common standard of hydrographic surveying using similar methods and producing a standard form of final chart. Under agreements reached with Australia and New Zealand each country can print and distribute each other's charts directly from material provided by the charting country.

So the endless task of exploring the seas continues, with Great Britain still one of the foremost nations in the field—thanks to the solid foundations laid by our predecessors who so clearly saw how essential to a maritime nation is the efficient fulfilment of this great and rewarding work.

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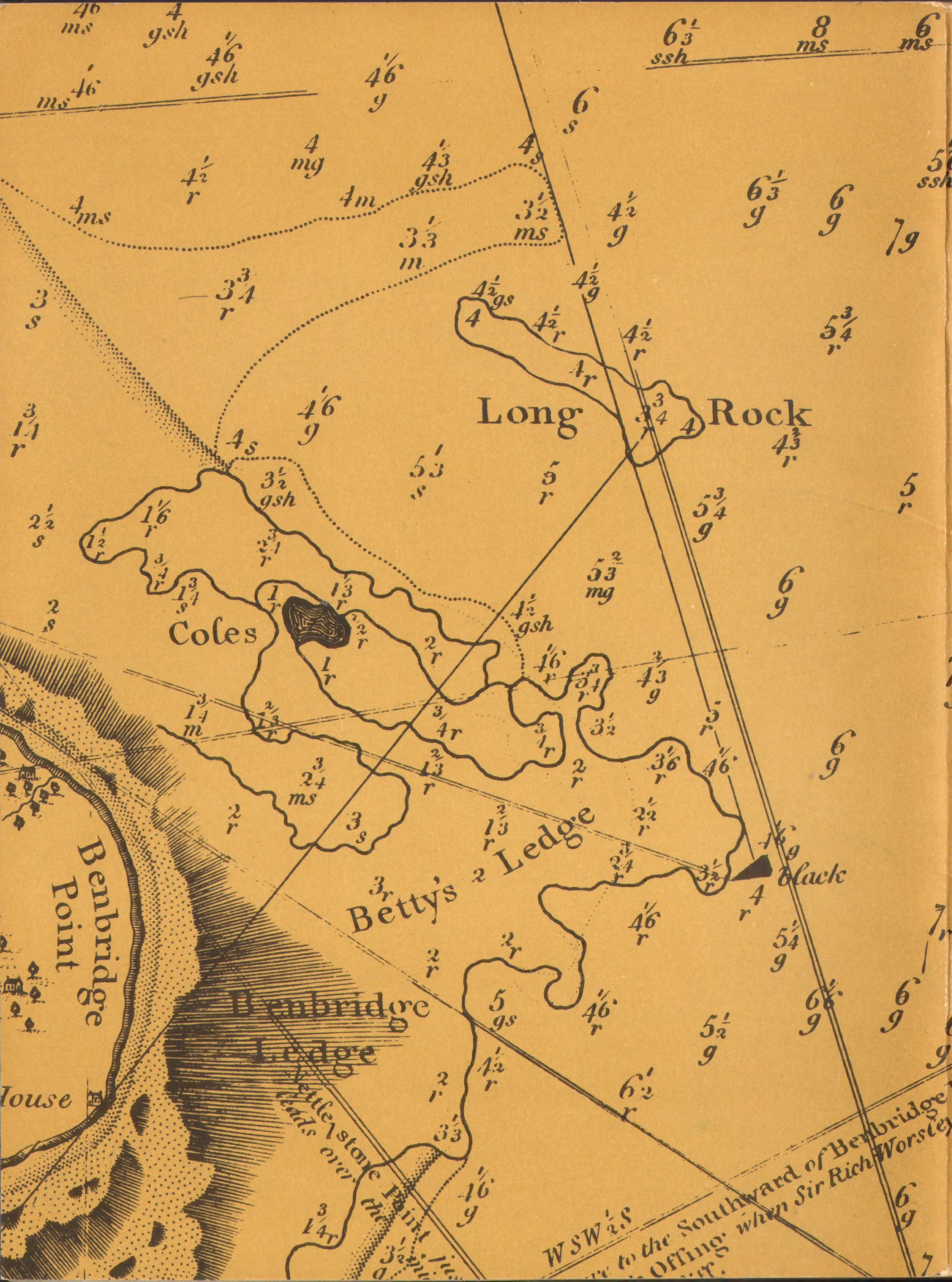
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